Attentional Trade-offs under Resource Scarcity

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Abstract. Resource scarcity poses challenging demands on the cognitive system. Budgeting with limited resources induces an attentional focus on the problem at hand, but it also comes with a cost. Specifically, scarcity causes a failure to notice beneficial information in the environment, or remember to execute actions in the future, that help alleviate the condition of scarcity. This neglect may arise as a result of attentional narrowing. Attentional trade-offs under scarcity can further determine memory encoding. In five experiments, we demonstrated that participants under scarcity prioritized price information but neglected a useful discount when ordering food from a menu (Experiment 1); they showed better recall for information relevant to the focal task at a subsequent surprise memory test (Experiments 2 and 3); they performed more efficiently on the focal task but neglect a useful cue in the environment that could save them resources (Experiment 4); and they failed to remember the previous instructions to execute future actions that could save them resources (Experiment 5). These results collectively demonstrate that scarcity fundamentally shapes the way people process information in the environment, by directing attention to the most urgent task, while inducing a neglect of other information that can be beneficial. The attentional neglect and memory failures may lead to suboptimal decisions and behaviors that further aggravate the condition of scarcity. The results provide new insights on the behaviors of the poor, and also important implications for public policy and the design of welfare services and programs for low-income individuals.

Keywords: Poverty, Visual attention, Memory, Encoding, Decision making

Introduction

Scarcity is an urgent and pervasive problem in the world: Roughly 1.2 billion people live in extreme poverty with less than $1.25 a day, 1.3 billion people live without electricity, and more than 780 million lack access to clean water. Scarcity is the condition of having insufficient resources to cope with the demands, and presents significant challenges to the cognitive system. For example, having limited financial resources requires the meticulous calculation of any expenses. Similarly, having limited time requires stringent management of schedules.

The cognitive consequences of scarcity are recently revealed by a number of studies [14]. For example, scarcity causes myopic behavior which results in the neglect of future events [18]. Specifically, people under scarcity tend to prioritize the task at hand and over-borrow resources from the future. Financial scarcity directly impairs cognitive function, reducing fluid intelligence and the ability to exert cognitive control [12]. These cognitive and behavioral consequences are particularly problematic because these impairments can lead to suboptimal decision making and behaviors (e.g., poor time management or financial planning skills) that further perpetuate the condition of scarcity.

Currently, it is still unclear what cognitive mechanisms underlie the impairments caused by scarcity. A possible explanation is that scarcity presents urgent demands that hijack attentional resources, causing a strong focus on the task at hand. Such focus can induce a neglect of other potentially important information.

Support for this explanation comes from the previous theoretical and empirical work on the limits of the cognitive system. Specifically, the cognitive system has a finite capacity, and people can only receive and process a limited amount of information at a time [1, 11, 13, 15]. Given this limited capacity, engaging in one process consumes cognitive resources needed for another, thus causing interference. For example, studies on inattentional blindness [20] show that performing a demanding task (e.g., counting how often the basketball is passed around) results in an inability to notice a salient event (e.g., a man dressed as a gorilla passing by). Basic visual features of unattended stimuli may not even be perceived [17]. In addition to perception, this interference can cause serious behavioral consequences such as impaired driving [21]. The limited cognitive resources given competing demands can thus result in attentional trade-offs between focus and neglect.

Here, we propose that scarcity forces attentional trade-offs. Specifically, people operating under scarcity may prioritize urgent tasks at hand, leaving other information unattended. This process can be counter-productive because the attentional neglect can cause the failure to notice useful and beneficial information in the environment that alleviates the condition of scarcity. To investigate the attentional trade-offs under scarcity and the resulting cognitive consequences of such trade-offs, we conducted five experiments in the current study.

Experiment 1

The goal of this experiment was to examine the effects of scarcity on visual attention. We predict that scarcity draws attention to the information relevant to the task at hand, but at the same time, also causes the neglect of other useful information in the environment.

Participants

One hundred and ninety undergraduate students (152 female, 35 male, 3 unspecified; mean age = 20.39 years, *SD* = 3.92) were recruited from the Human Subject Pool at the Department of Psychology at the University of British Columbia (UBC), and participated in the experiment for course credit. Participants in all experiments reported normal or corrected-to-normal vision and provided informed consent. All experiments reported here were approved by the UBC Behavioral Research Ethics Board.

Stimuli and Procedure

Participants were presented with a restaurant menu which contained 24 food items. For each item, the price and the calories were listed in two columns on the menu (Figure 1). The menu subtended 12.4° of visual angle in width and 16.2° in height. A discount clause was shown on the bottom of the menu ("You may ask for an 18% student discount.").

Participants were randomly assigned with either a small budget ($20; the poor condition) or a large budget ($100; the rich condition). Thus, the experiment used a between-subjects design. Participants were asked to view the items on the menu and think about what they would like to order, as if they were ordering a meal from a restaurant. They were given unlimited time to place the order, and were told not to exceed the assigned budget, but they were not required to spend the entire budget.

The eye gaze of each participant was monitored throughout the experiment using SMI RED-250 Mobile Eyetracking System (60hz). To examine which part of the menu was attended to, the menu was divided into four areas of interest: food items (left column), price information (middle column), calorie information (right column), and discount clause (on the bottom).

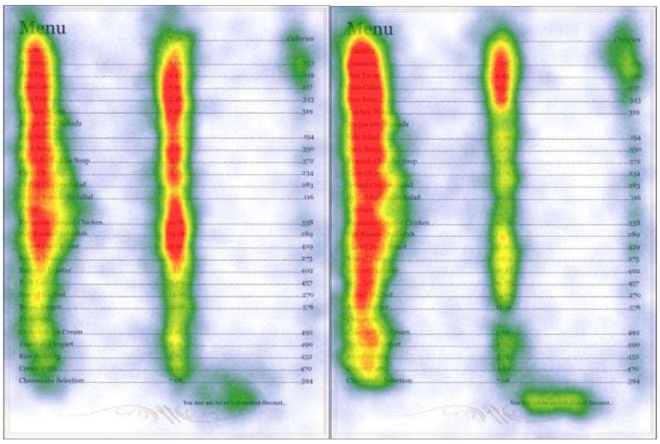

Fig. 1. Left: A heat map of the menu showing the distribution of the average dwell time for the participants in the poor condition (who ordered a meal with $20). Right: A heat map showing the distribution of the average dwell time for the participants in the rich condition (who ordered a meal with $100). Warmer colors represent longer average dwell time.

Results and Discussion

To measure visual attention, we calculated the dwell time and the number of fixations in each area of interest. The heat maps of the average duration of dwell time between the poor and the rich conditions were shown in Figure 1.

Since there was no time limit in the experiment, participants could spend as much time as they needed to make the order. We found that participants in the rich condition took more time to order (*M* = 89 seconds) than the participants in the poor condition (*M* = 76 seconds) [$t(188) = 2.24$, $p = .03$, $d = .33$]. Thus, we used the proportional dwell time (the dwell time spent in each area divided by the total dwell time on the menu) and the proportional fixations (the number of fixations in each area divided by the total number of fixations on the menu) as two measures of visual attention. In addition, participants with more than 3 standard deviations away from the mean in each measure were excluded (between 1 and 4 participants in total, depending on the measure).

For the food items (Figure 2), participants in the poor condition spent less dwell time (*M* = 35.11%) than those in the rich condition (*M* = 51.98%) [$t(185) = 3.91$, $p < .001$, $d = .57$]. The poor also made few fixations (*M* = 36.66%) on the food items than the rich (*M* = 48.50%) [$t(187) = 3.08$, $p = .002$, $d = .45$]. This suggests that the poor participants spent less time considering which food items they would like to order than the rich participants did.

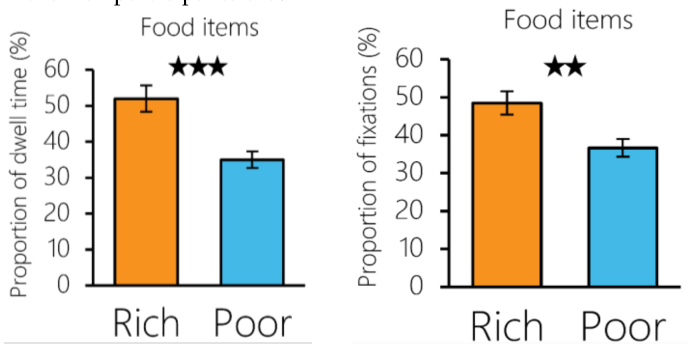

Fig. 2. The proportional dwell time and fixations on food items between participants in the poor and the rich conditions (error bars reflect ±1 SEM; $**p<.01$, $***p<.001$).

For price information (Figure 3), participants in the poor condition dwelled longer at prices (*M* = 21.08%) than those in the rich condition (*M* = 15.23%) [$t(185) = 2.16$, $p = .03$, $d = .32$]. Participants in the poor condition also made more fixations on prices (*M* = 23.07%) than those in the rich condition (*M* = 15.81%) [$t(185) = 2.91$, $p < .01$, $d = .43$]. This suggests that the poor attended more to prices than the rich participants.

This result could be driven by the possibility that scarcity enhanced attention to all numerical information. Thus, we examined attention to the calorie information (Figure 4). Participants in the poor condition dwelled less on calories (*M* = 2.92%) than those in the rich condition (*M* = 4.35%) [$t(185) = 2.65$, $p < .01$, $d = .39$]. The poor (*M* = 3.51%) also made fewer fixations on calories than the rich did (*M* = 5.09%) [$t(184)$

= 2.39, *p* = .02, *d* = .35]. This indicates that financial scarcity draws attention more to prices and induces a neglect of calories.

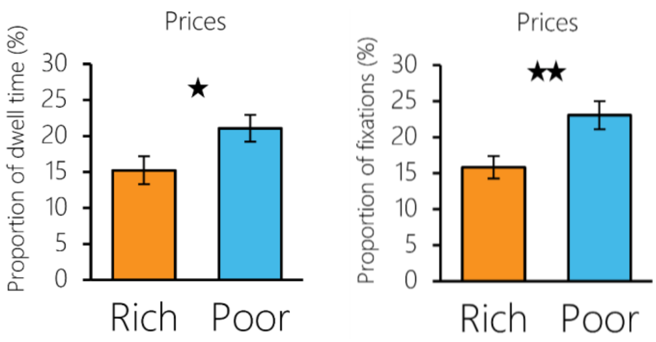

Fig. 3. The proportional dwell time and fixations on prices between participants in the poor and the rich conditions (error bars reflect ±1 SEM; **p*<.05, ***p*<.01).

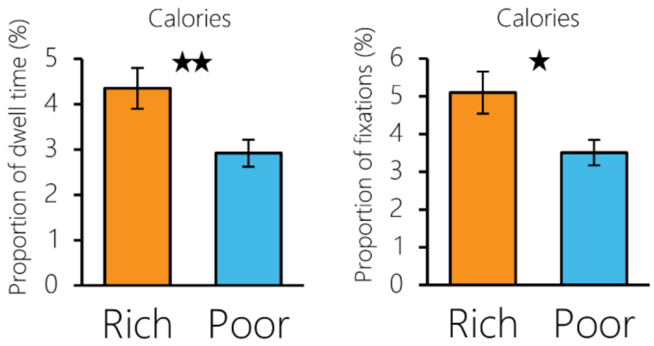

Fig. 4. The proportional dwell time and fixations on calories between participants in the poor and the rich conditions (error bars reflect ±1 SEM; **p*<.05, ***p*<.01).

Importantly, for the discount clause (Figure 5), participants in the poor condition spent less dwell time (*M* = 0.83%) than those in the rich condition (*M* = 1.83%) [*t*(184) = 3.51, *p* < .001, *d* = .52]. The poor also made fewer fixations on the discount clause (*M* = 0.85%) than the rich (*M* = 1.82%) [*t*(184) = 3.51, *p* < .001, *d* = .52]. This suggests that the poor neglected the discount, compared to the rich participants.

As another measure of attention to the discount, after placing the order the participants were asked if they had noticed other information on the menu besides the price and calorie information. While measures of visual attention showed that the poor looked less at the discount than the rich did, there was no reliable difference between the number of poor (*N* = 36) and rich (*N* = 33) participants who explicitly reported noticing the discount [$X^2(1,190) = .09$, *p* = .76].

An alternative explanation for the finding that the poor attended less to the discount was that scarcity might result in more efficient processing of task-relevant information. This would suggest that the poor did not need to look at the discount as much as the rich, because they were faster in seeing the discount. Since both the prices and the discount were task-relevant, this explanation would predict that the poor would be efficient in processing both price information and the discount. However, we found that the poor looked more at the prices but less at the discount than the rich did, which could not be explained by the efficiency account.

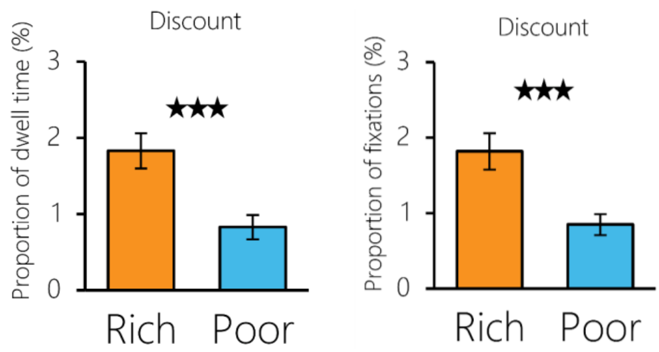

Fig. 5. The proportional dwell time and fixations on the discount clause between participants in the poor and the rich conditions (error bars reflect ±1 SEM; ****p*<.001).

The discount on the menu could in theory help the poor participants save money and stay within their budget. Despite this usefulness, the poor participants still neglected the discount and focused more on the prices of the food items. This finding is ironic and could help explain why the low-income individuals engage in neglectful behaviors that are counter-productive.

Experiment 2

Experiment 1 demonstrated that financial scarcity prioritizes the processing of price information, at the cost of other useful information. Given the attentional prioritization of prices, we predict that memory encoding of prices will also be enhanced. This prediction is supported by the recent work that suggests that visual working memory can be construed as visual attention preserved internally over time [2, 3]. Feature-based theories of attention also predict selective facilitation in visual processing for task-relevant features [8, 9]. Thus, in Experiment 2 we examined the effects of scarcity on memory encoding, as a result of attentional prioritization. We predict that financial scarcity facilitates memory encoding specifically for price information, and not for other types of information.

Participants

A new group of 60 undergraduate students (43 female, 17 male; mean age = 19.95 years, *SD* = 2.30) from UBC participated in the experiment for course credit.

Stimuli and Procedure

To increase the demand for memory encoding, we increased the number of items on the menu. Participants were presented with a menu which now contained 50 food items. As in Experiment 1, the menu included the price and calories for each food item. Participants were asked to place a meal order from the menu as if they were ordering from a restaurant. There was no set time limit for participants to place their order. As before, participants were randomly assigned with a small budget ($20; the poor condition) or a large budget ($100; the rich condition). The experiment again used a between-subjects design.

After participants placed their order, they were immediately given a surprise memory test. Participants were asked to recall as many items from the menu as possible. For each item recalled, they were also asked to recall the price and the calorie information of the item as accurately as possible.

Results and Discussion

To measure memory encoding, we calculated the average absolute error between the recalled prices (and calories) and the objective prices (and calories) for each participant (Figure 6). Participants in the poor condition (*Mean error* = $1.32) were reliably more accurate in the price recall than those in the rich condition (*Mean error* = $2.19) [$t(58) = 2.42$, $p = .02$, $d = .63$]. However, there was no reliable difference in the calorie recall between the poor and the rich participants [$t(58) = .81$, $p = .42$, $d = .21$].

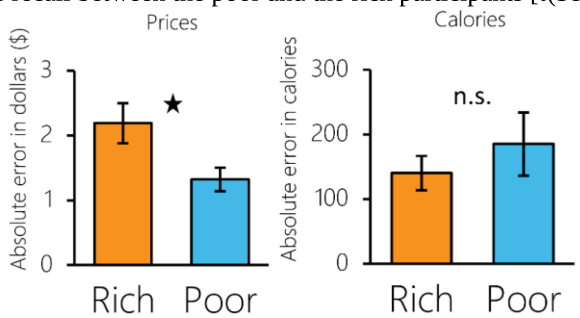

Fig. 6. The absolute error in the price recall and the calorie recall between participants in the price poor and the price rich conditions (error bars reflect ±1 SEM; *p<.01).

This enhanced performance in price recall in the poor cannot be explained by the fact that the poor participants ordered fewer items ($M = 2.13$) than the rich ($M = 3.70$) [$t(58) = 3.85$, $p < .001$, $d = .99$]. First, there was no reliable difference in the number of recalled times between the poor and the rich [$t(58) = 1.38$, $p = .17$, $d = .36$]. Second, there was no difference in the time taken to place the order between the poor and the rich participants [$t(58) = 1.58$, $p = .12$, $d = .41$]. Third, even if ordering fewer items might improve memory recall, this benefit would be seen in both price and calorie recall, but we found that the poor were more accurate only in price recall, not in calorie recall. Thus, these findings suggest that financial scarcity improves memory encoding for task-relevant information (i.e., prices), but not for task-irrelevant information (i.e., calories). Scarcity selectively facilitates memory encoding.

Experiment 3

To generalize the findings in Experiment 2 to a different domain, we examined how calorie scarcity affects memory encoding. We predict that calorie scarcity facilitates memory encoding specifically for calorie information, and not for price information.

Participants

A new group of 60 undergraduate students (49 female, 11 male; mean age = 20.03 years, *SD* = 2.11) from UBC participated in the experiment for course credit.

Stimuli and Procedure

The stimuli and the procedure were identical to those in Experiment 2, except for a critical difference. Participants were randomly assigned with a small calorie budget (500 calories; the poor condition) or a large calorie budget (2000 calories; the rich condition). As before, participants were then asked to place a meal order from the menu as if they were ordering from a restaurant. After the order, participants were given a surprise memory test, where they recalled items from the menu with the price and calorie information.

Results and Discussion

To measure memory encoding, we calculated the average absolute error between the recalled calories (and prices) and the objective calories (and prices) for each participant (Figure 7). Participants in the poor condition (*Mean error* = 48.05) were reliably more accurate in the calorie recall than those in the rich condition (*Mean error* = 71.61) [$t(58) = 2.27$, $p = .03$, $d = .58$]. This suggests that the calorie poor showed better memory encoding of calorie information than the calorie rich.

A critical test of our prediction was whether this memory facilitation is specific to task-relevant information (i.e., calories). We found that there was no reliable difference in the price recall between the two conditions [$t(58) = 0.19$, $p = .85$, $d = .04$]. Thus, memory encoding was selectively enhanced for the calorie information in the calorie poor participants. Interestingly, we did not observe worse memory encoding for the task-irrelevant information. That is, the calorie recall was the same for the price poor and the price rich in Experiment 2, and the price recall was the same for the calorie poor and the calorie rich in Experiment 3. The lack of difference between the rich and poor in memory encoding of task-irrelevant information could be driven by the possibility that neither the rich nor the poor needed to pay attention to this information in these experiments.

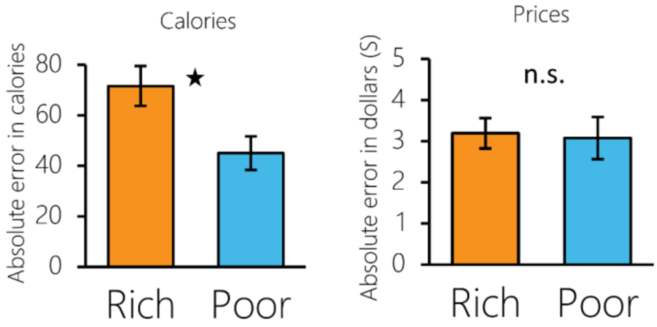

Fig. 7. The absolute error in the calorie recall and the price recall between participants in the calorie poor and the calorie rich conditions (error bars reflect ±1 SEM; *p<.01).

Experiment 4a

In this experiment we investigated how time scarcity affects the online detection of information. Past work shows that people only start to increase their efforts to accomplish their goals when a deadline becomes salient [4]. Further, time pressure causes fewer attributes to be considered when choosing between alternatives [22]. The goal of this experiment was to investigate how time scarcity affects the online detection of information in the environment. We hypothesize that time scarcity draws attention to the focal task, while inducing neglect of other useful information in the environment.

Participants

Undergraduate students (N = 90) were recruited from the UBC Human Subject Pool, and participated in the experiment in exchange for course credit.

Stimuli and Procedure

Each participant was asked to solve a series of puzzles on the computer screen. The puzzles were 50 trials of the Raven's Progressive Matrices [16]. Each matrix appeared at the centre of the screen, and contained a pattern of objects. The bottom right corner of the matrix was missing, and participants had to find the right piece that fits with the general pattern in the matrix. The participant was asked to correctly solve as many matrices as possible in exchange for points. In each trial, participants were presented with one Raven's matrix, with the numbered pieces appearing below. The response keys appeared in a vertical list on the left side of the screen. In the top-left corner of the screen, the questions number and time remaining were displayed (see Figure 8). To solve a given matrix, participants had to press a number key that corresponds to the piece that fits into the missing corner of the matrix.

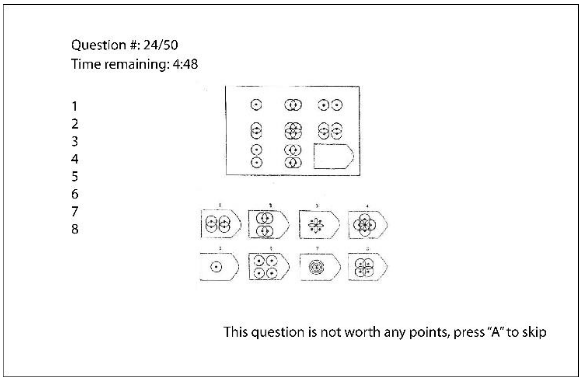

Fig. 8. Trial screen for Experiment 4a.

To manipulate time scarcity, participants were randomly assigned with either a rich time budget (they had 40 minutes in total to solve the matrices; the time-rich condition, $N = 45$), or a poor time budget (they only had 10 minutes in total to solve the matrices; the time-poor condition, $N = 45$). Without explicit instruction or prompting, a time-saving cue appeared in the lower right part of the screen during the experiment. Specifically, on even-numbered trials starting from trial #24, the cue appeared on the screen stating: "This question is not worth any points. Press 'A' to skip." (see Figure 8) Thus, 14 of the 50 trials were allowed to be skipped without any loss of points. The cue appeared at the same time as the matrix for those trials, and remained on the screen for 5000ms, and then disappeared. These trials presented an opportunity to skip the question in order to save time. Participants were not told anything about the cue. We wanted to see if they were able to detect this message during the experiment and skipped the even-numbered questions from trial #24.

Results and Discussion

Participants in the time-poor condition almost unanimously used their entire time budget while participants in the time-rich condition used less than half of their time budget. Given this constraint, the time-poor participants spent less time on the task overall compared to time-rich participants [$t(88) = 6.51$, $p < .001$, $d = 1.37$] (Figure 9a). The time-poor participants completed fewer trials than the time-rich participants [$t(88) = 4.71$, $p < .001$, $d = .99$] (Figure 9b).

Notably, there was marginal difference in accuracy on the Raven's Progressive Matrices between the time-poor and the time-rich participants [$t(88) = 1.69$, $p = .09$, $d = .36$] (Figure 9c). When accounting for the total amount of time spent on the task, the time-poor participants scored higher accuracy per minute than time-rich participants [$t(88) = 8.09$, $p < .001$, $d = 1.71$]. This result suggests that time scarcity can cause a greater focus on the task at hand, enhancing task performance within the time limit.

Examining the number of questions skipped, we found that there was no difference in the average number of questions skipped between the time-poor and the time-rich participants [$t(88) = 1.23$, $p = .22$, $d = .26$] (Figure 9d). However, only 26.7% of the participants in the time-poor condition skipped at least once, and there were more time-rich participants (48.9%) who skipped at least once [$X^2(1,90) = 4.72$, p = .03] (Figure 9e). This result suggests that time scarcity caused a failure to use the time-saving cue appearing on the bottom of the screen.

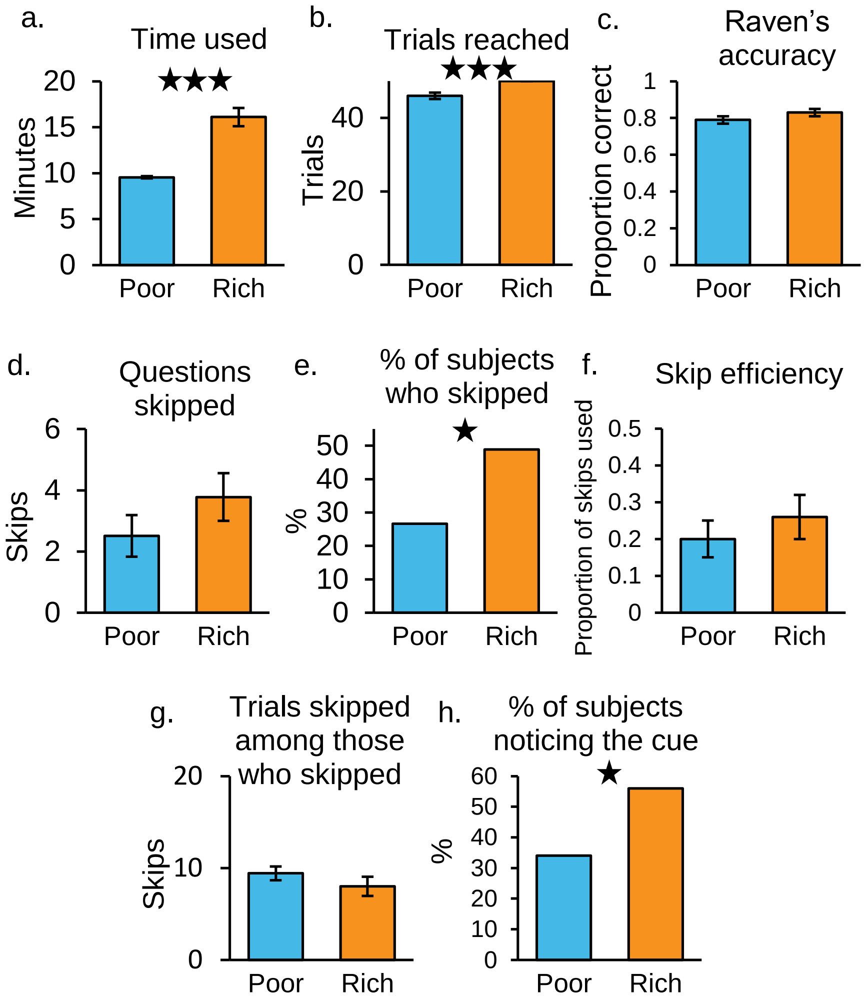

Fig. 9. Results for Experiment 4a (Error bars represent ±1SEM. **p*<.05, ****p*<.001).

To control for the total number of trials completed, we calculated skip efficiency as the number of questions skipped divided by the number of possible questions that could be skipped. There was no difference in skip efficiency between the time-poor and the time-rich participants [$t(88) = .91$, p = .36, d = .19] (Figure 9f).

Among those who skipped at least once, there was no difference in the number of questions skipped between the time-poor and the time-rich participants [$t(31) = .89$, $p = .38$, $d = .34$] (Figure 9g). This means that if the participant noticed the cue at least once, they were able to skip the same number of questions, regardless of scarcity.

To measure retrospective recall of the time-saving cues, we asked participants after completing the task during debriefing to report whether they saw any messages appearing on the screen during the task. We found that the time-poor participants were less likely to report seeing the cues than the time-rich participants [$X^2(1,84) = 3.81$, $p = .05$] (Figure 9h).

These results showed that fewer participants under time scarcity skipped the questions at least once, and reported seeing the cues, compared to time-rich participants. This suggests that time scarcity may narrow attention to the central task, while inducing a neglect of peripheral, even beneficial information in the environment. An alternative explanation is inattentional blindness, suggesting that the time-poor participants were less able to attend to salient but task-irrelevant information, than the time-rich participants. To tease these two accounts apart, we conducted the next experiment, probing whether scarcity alters the spatial scope of attention, or the ability to notice salient stimulus. Specifically, we manipulated the location of the time-saving cue, and examined the likelihood of skipping questions as a function of the spatial location of the cue under scarcity.

Experiment 4b

In this experiment, we reduced the spatial distance between the time-saving cue and the matrix (i.e., the focal task) by moving the cue closer to the center of the screen, and investigated how the spatial proximity of the time-saving cue to the focal task impacted its detection.

Participants, Stimuli, and Procedure

Participants ($N = 87$) were recruited from the Human Subject Pool at UBC, and participated in the experiment in exchange for course credit. The stimuli and the procedure were exactly the same as those in Experiment 4a, except one important change: the time-saving cue (i.e., the message to skip even-numbered questions after trial #24) now appeared directly underneath the Raven's Matrix after trial #24 for even-numbered questions (Figure 10).

If the neglect of the time-saving cue in Experiment 4a was due to the spatial narrowing of attention under scarcity, we would predict that the time-poor participants would be more likely to notice the cue if it were moved closer to the central task. On the other hand, if the neglect of the time-saving cue was due to inattentional blindness, moving the cue closer to the central task would not affect performance.

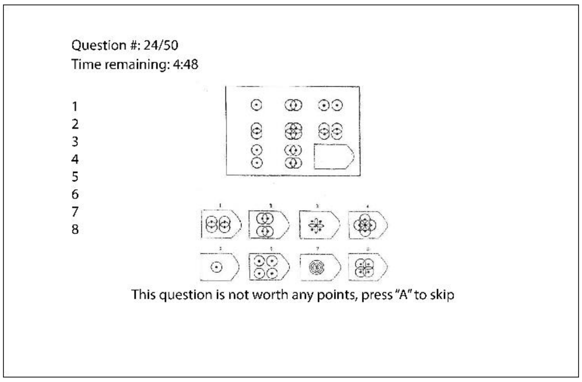

Fig. 10. Trial screen for Experiment 4b, where the time-saving cue appeared right below the matrix.

Results and Discussion

Since in Experiment 4a, time scarcity influenced the number of participants who skipped at least once, we examined the same measure here again. We found that now there was no statistical difference in the percent of participants who skipped at least once [$X^2(1,87) = .56$, $p = .46$]. Comparing Figure 11a to Figure 9e, the time-rich participants were not influenced by the change in the position of the cue, but the poor seemed to benefit from the closer proximity of the cue to the central task. This suggests that if the cue falls within the spatial scope of attention, the time-poor participants could still take advantage of the cue.

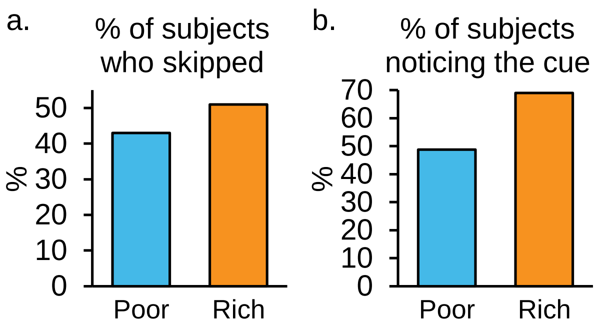

Fig. 11. Results for Experiment 4b.

During debriefing, the time-poor participants were marginally less likely to report seeing any messages during the task compared to the time-rich participants [$X^2(1,85) = 3.583$, $p = .06$] (Figure 11b). Compared to the time-poor participants in Experiment 4a (34% reported noticing the cue), the closer proximity seemed to provide a large benefit to the time-poor participants in Experiment 4b (49% reported noticing the cue). These results support the account that scarcity narrows spatial attention to the focal task.

Experiment 4c

To further explore the boundary condition of the spatial narrowing effect of scarcity, in this experiment we moved the time-saving cue farther away from the focal task, and examined how likely participants were to notice the cue.

Participants, Stimuli, and Procedure

Participants (*N* = 86) were recruited from the Human Subject Pool at UBC, and participated in the experiment in exchange for course credit. The stimuli and the procedure were identical to those of Experiment 4a, but this time the time-saving cue appeared in the bottom right corner of the screen (Figure 12), which was even farther away from the focal task than in Experiment 4a.

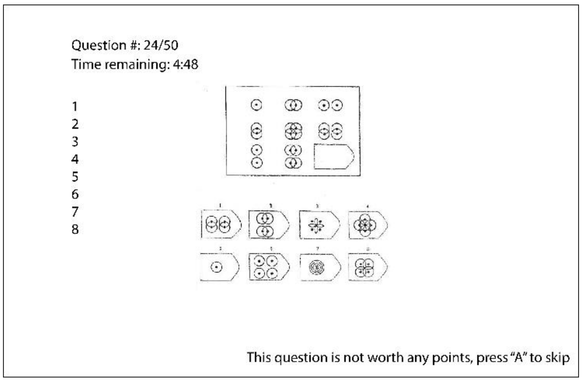

Fig. 12. Trial screen for Experiment 4c, where the time-saving cue appeared far from the matrix, on the bottom right corner of the screen.

Results and Discussion

We found that participants in both conditions failed to take advantage of the cue. There was no difference in the percent of participants who skipped at least once [$X^2(1,86) = .93$, $p = .33$] (Figure 13a). During debriefing, there was no difference in the likelihood to report seeing any messages during the task between both conditions [$X^2(1,83) = 2.00$, $p = .16$] (Figure 13b). In fact, there was a floor effect in both the time-poor and the time-rich participants in skipping the questions or noticing the cue. This suggests that when the cue was spatially far away from the focal task, participants could not notice the cue, regardless of scarcity.

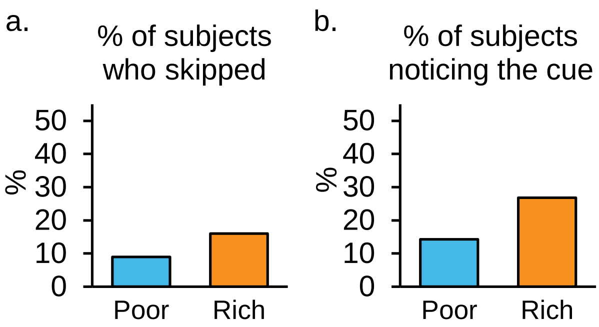

Fig. 13. Results for Experiment 4c.

Experiment 5

Experiments 4a-c showed that time scarcity narrowed attention on the focal task, resulting in the neglect of a time-saving cue which appeared in the peripheral during the experiment. However, in daily life, we do not always have cues in the external environment as reminders for certain actions. Instead, we need to rely on internal cues from memory that need to be activated at the right time to direct actions. For example, in order to pick up groceries on the way home from work, we must remember to turn at the right intersection in order to go to the grocery store. This depends on prospective memory, which is the ability to remember to executive future actions based on previous instructions. Cues for prospective memory are internal, and must be present in mind in order to cue behavior at the right time [6, 10]. In this experiment, we examined how time scarcity affects prospective memory performance.

Participants

Participants (N = 90) were recruited from the Human Subject Pool at UBC and completed the study in exchange for course credit.

Stimuli and Procedure

Participants were asked to solve the same set of 50 Raven's Progressive Matrices used in Experiments 4a-c. As before, participants were randomly assigned either a small time budget (5 minutes; the time-poor condition), or a large time budget (20 minutes; the time-rich condition). A critical difference in this experiment was that the time-saving cue never appeared in the experiment. Rather, all participants were explicitly instructed at the start of the experiment the following: "Even-numbered questions from number twenty-four on are not worth any points. You can skip these questions without losing any points." This instruction was presented on paper to participants to read, and the experimenter also read through these instructions with each participant to maximize the comprehension of the instruction. As before, the question number and remaining time appeared in the top-left corner of the screen, and the keys available for the participants to press were listed on the left side of the screen. Note that now the "A (skip)" key is listed among the available keys and was listed for every single question (Figure 14). There were no visual cues during the experiment to remind participants which questions they were allowed to skip. Thus, participants needed to remember to use the opportunity to skip when the applicable questions were reached.

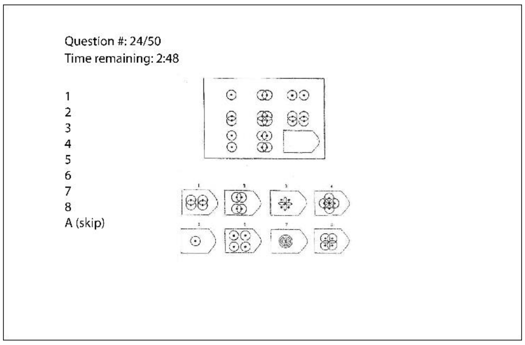

Fig. 14. Trial screen for Experiment 5.

Results and Discussion

Participants in the time-poor condition almost unanimously exhausted their time budgets, while participants in the time-rich condition usually completed the experiment with some time to spare (Figure 15a). The time-poor participants spent less time solving the Raven's Matrices than the time-rich participants [$t(88) = 13.33$, $p < .001$, $d = 2.81$]. They also completed significantly fewer trials than the time-rich participants [$t(88) = 10.14$, $p < .001$, $d = 2.14$] (Figure 15b), and were significantly less accurate [$t(88) = 2.29$, $p = .02$, $d = .48$] (Figure 15c). When accounting for the total amount of time spent on the task, the time-poor participants scored higher accuracy per minute than time-rich participants [$t(88) = 9.53$, $p < .001$, $d = 2.01$], suggesting that time scarcity enhancing performance on the focal task.

The time-poor participants on average skipped fewer questions than the time-rich participants [$t(88) = 2.52$, $p = .01$, $d = .53$] (Figure 15d). However, this result is likely driven, at least in part, by the considerably smaller number of questions completed by the time-poor participants. Similarly, we found that fewer time-poor participants skipped at least once compared to the time-rich participants [$X^2(1,90) = 10.08$, $p < .01$] (Figure 15e), but this could be due to the smaller number of possible skips experienced by the time-poor participants. Thus, we examined the skip efficiency defined as the number of questions skipped divided by the number of possible questions that could be skipped experienced by the participant. We found that the time-poor participants were less likely to skip than time-rich participants (two time-poor participants were excluded from this analysis due to failing to reach trial number twenty-four) [$t(86) = 2.01$, $p = .05$, $d = .43$] (Figure 15f). This finding suggests that time scarcity impairs prospective memory performance. We should note that among participants who skipped at least once, there was no difference in the number of questions skipped between the time-poor and the time-rich participants [$t(40) = .59$, $p = .56$, $d = .19$] (Figure 15g), or in skip efficiency [$t(40) = .76$, $p = .45$, $d = .26$] (Figure 15h).

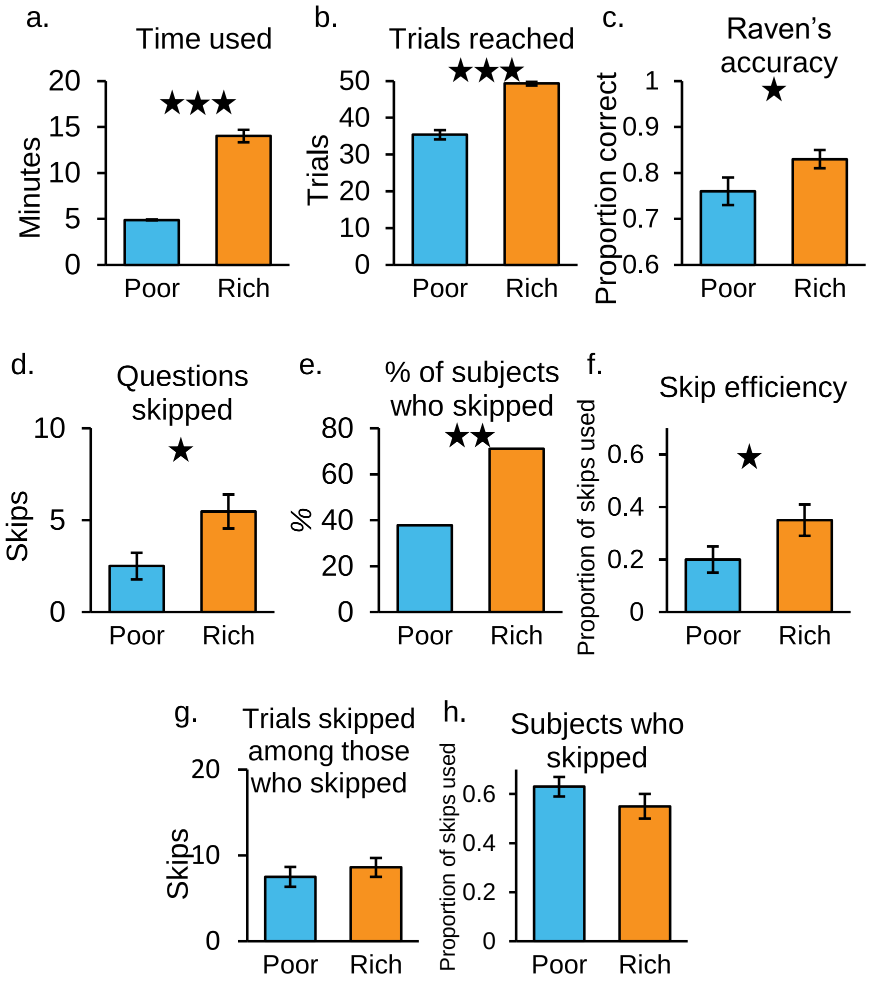

Fig. 15. Results for Experiment 5 (Error bars represent ±1SEM. *p<.05, **p<.01, ***p<.001).

General Discussion

The goal of the current study was to examine how scarcity forces attentional trade-offs and influences memory encoding driven by such trade-offs. When operating under a limited financial budget, the poor focused more on the price information, compared to the rich (Experiment 1). This focus came with the neglect of other information in the environment, even if the information could be useful or beneficial to the poor (e.g., the discount). The attentional prioritization of prices also resulted in enhanced memory encoding of price information among the poor participants (Experiment 2). Likewise, the attentional prioritization of calories led to better memory encoding of calorie information among the calorie poor (Experiment 3). We also found that people under time scarcity were less likely to take advantage of a time-saving cue that appeared peripheral to the focal task (Experiment 4a), but nonetheless performed well on the focal task under the time constraint. This suggests that people under time scarcity are ironically less likely to notice opportunities to save time. This effect could be explained by a narrowing of spatial attention to the focal task (Experiments 4b & 4c). In the absence of an external cue, participants under time scarcity were less likely to remember to skip questions in the future (Experiment 5), suggesting that they failed to retrieve a cue from memory to execute actions at the right time.

These findings were particularly problematic for people under scarcity because the attentional neglect of resource-saving opportunities or the failure to remember to save resources could be detrimental, perpetuating the condition of scarcity and creating a vicious cycle of poverty. These cognitive impairments could explain a range of counter-productive behaviors observed in the low-income individuals, such as forgetting to follow instructions, or not signing up for public benefit programs. In addition, prospective memory errors can be seen by others as an indication of incompetence of the poor [5]. The present findings instead attribute the memory failures not to the poor individuals themselves but to the condition of scarcity. The current study provides useful implications for designing policies and programs to mitigate the impact of scarcity, such as the use of reminders, automatic enrolment, or setting the right default, to reduce the attentional and memory burdens in the poor.

The current findings provide a new perspective on how scarcity shapes the way people perceive and experience the external environment. While the perceptual experiences can be largely characterized by information overload, scarcity selectively orients people’s attention to specific aspects of the environment. When operating with financial constraints, people automatically prioritize price-relevant information. Such prioritization facilitates memory encoding of these information, but crucially it comes with a cost, which is the neglect of other information in the environment.

The current study also reveals a painful irony of scarcity. People with limited resources were too focused on prices, such that they neglected the beneficial discount that could save money and alleviate the financial burden. This irony can help explain why low-income individuals sometimes engage in neglectful behaviors that are counter-productive (e.g., missing an appointment for a health checkup, or failure to sign up for benefit programs).

It is worth noting that the current experiments involved an artificial simulation of scarcity in the lab. In fact, just by randomly assigning people to receive a hypothetical small or large budget, we observed a strong effect of scarcity on attention and memory. Moreover, the participants in our experiments were not provided with real money, were not rewarded for frugality, and knowingly were not to receive any food from the menu. In the absence of possible consequences of their decisions, the poor participants still focused on task-relevant information and neglected a help to alleviate the condition of scarcity. This raises the possibility that, outside the lab when people operate with scarce resources and can face real consequences of their actions, the effects of scarcity on attention and cognition observed in this study may be amplified.

The current findings can help inform public policy and services targeting low-income populations. Among the OECD countries, enrollment in social assistance and public benefit programs is estimated to range between 40% and 80% [7]. Our current study provides a new explanation for the low participation rate. That is, the poor who are eligible for these programs fail to participate because of the attentional trade-offs under scarcity. Low-income individuals may need to focus on their financial challenges and deadlines under scarcity, and either are not aware of these benefit programs and services, or neglect the enrollment procedures. This attentional account is not the only factor that can explain the low participation rate, as there are many other social barriers and stigmas related to enrollment in assistance programs.

Given the attentional constraints under scarcity, we propose that social assistance and public benefit programs should be designed to avoid the attentional neglect in the poor under scarcity. It may be helpful to streamline assistance applications and services to make them more salient, more accessible, and easier to process for the poor. The amount of effort and attention required from the poor should be minimized to increase or maintain participation. Benefit programs and social services can also be made more salient by using prompts and reminders. This could be done through any messaging medium such as text-message or email, and could be effective in catching the attention of those living under scarcity. Based on our current findings, future research can design behavioral interventions to avoid attentional neglect in the poor. Future studies can also test the hypothesis that certain mindfulness training programs (e.g., EEG-enhanced biofeedback) would reduce the cost of scarcity-induced attentional bias, through a reduction of reactivity to scarcity-related thoughts and emotions.

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